

Investigation of the Effect of Milling Time on Elemental Powders of Oxi-Reduction Nickel and Hydrogenation–Dehydrogenation Titanium

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Mechanical alloying (MA) is widely applied in the synthesis of blended elemental or prealloyed powders. This work evaluates the effect of milling time on elemental nickel and titanium powders produced by oxi-reduction and the hydrogenation–dehydrogenation process, respectively. The powders are characterized by scanning electron microscopy, X-ray diffraction, particle size, powder yield, and differential scanning calorimetry. It is observed that increasing the milling time promotes the formation of a structure composed of thin lamellae of nickel and titanium, which results in the beneficial effect of lowering the temperature for the formation of the intermetallic of the Ni–Ti system and in the powder yield achieved. The reduction of milling time in the MA process of NiTi alloys enhances technological efficiency by decreasing their overall processing time.

result in contamination by carbon and oxygen arising from graphite crucibles, in the case of VIM, and repeated melting, in the case of VAR. The presence of those elements may change the chemical composition, lead to a titanium depletion of the alloy, and promote changes in the phase transformation temperatures. A striking feature of the properties of NiTi SMAs is that they depend strongly on the exact chemical composition, processing history, and the presence of impurities.^[2,4,5]

Powder metallurgy is a technique widely applied in the manufacture of components in recent years due to benefits such as the reduction of impurities combined with

compositional control, the reduction of cost combined with the large-scale manufacture of components within dimension control, and the possibility of making composite materials by adding alloy elements.^[6–9]

Besides manufacturing NiTi alloys through casting, there are many ways to manufacture NiTi alloys, such as powder metallurgy. Currently, researchers are interested in obtaining porous NiTi alloys.^[10–15] In the case of casting, some difficulties must be addressed, such as, for instance, the presence of NiTi₂ and NiTi₃ phases and high porosity.^[2,4,11–15] Mechanical alloying (MA) is a powder metallurgy processing route adequate for synthesizing equilibrium and nonequilibrium alloy phases and applied to

1. Introduction

Shape memory alloys (SMAs), such as NiTi alloys (nearly equiatomic), have attracted widespread interest in different fields of engineering and biomedical applications due two important properties: shape memory effect (SME) and superelasticity (SE), along with good corrosion resistance, functional fatigue, and biocompatibility.^[1–4]

Several methods for manufacturing NiTi alloys on a laboratory scale have been studied in recent years. Many studies have used casting processes (such as vacuum induction melting (VIM) and vacuum arc remelting (VAR)). However, this processing may

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